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(71)(72) Applicant and Inventor: DISEL, Jimmy, D. [US/US]; 7073 Elmsdale Drive, San Jose, CA 95120 (US).

(74) Agents: DULIN, Jacques, M. et al.; Pillsbury Madison & Sutro L.L.P., Suite 800, 10 Almaden Boulevard, San Jose, CA 95113 (US).

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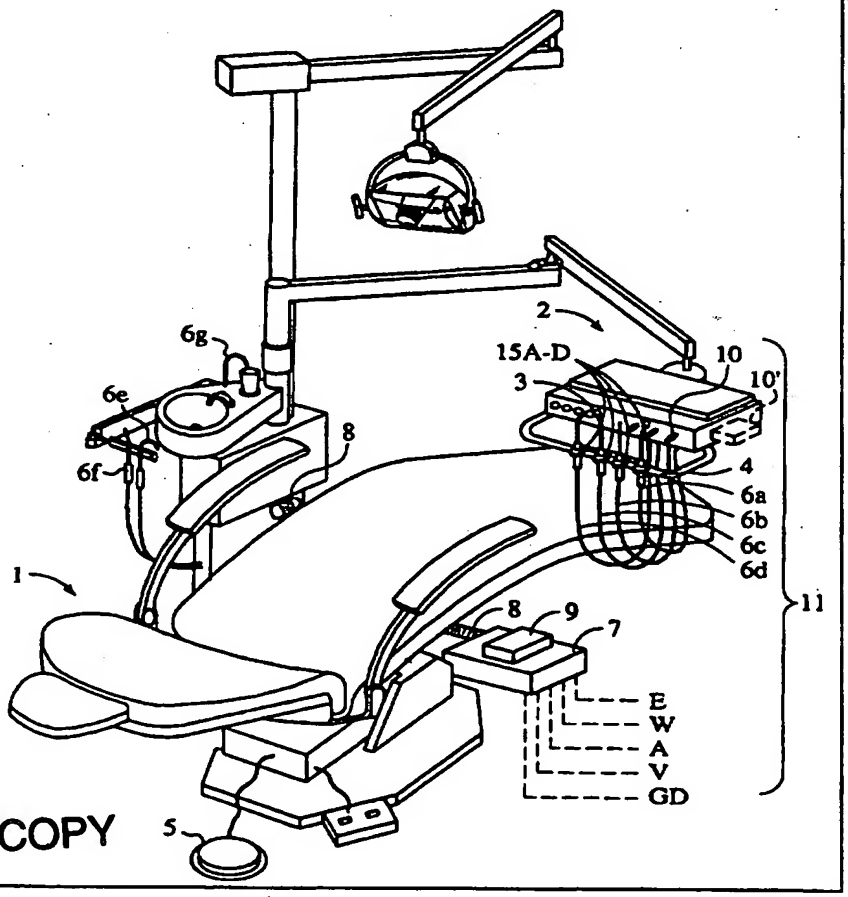
(57) Abstract

An automated antimicrobial (AMB) Flush System (11) and method for disinfecting a medical or dental handpiece unit (2). In a first PM (evening) cycle, disinfectant solution is first passed through a hose (6) of the dental unit (2), then the hoses (6) are rinsed or purged with water, and finally by air or vacuum. The air is provided prior to extended periods of non-use for drying the hose (6) which assists in preventing microbial (biofilm) growth therein. Prior to reuse an AM (daytime) cycle is run, in which the hose (6a-d) is again flushed with disinfectant solution and then purged with water to make the dental unit (2) ready for use. The dental unit (2) is made inoperative, locked-out, while the AMB flush system (11) is in operation, and until the hose (6a-d) has been finally purged of water. The AMB Flush System may be retrofit on present dental units or integrated therewith. A programmable timer (846) is disclosed for initiating the operation of the AMB Flush System (11) at times preselected by the operator. The AM cycle must be run after the PM cycle. That is, as an extra safety precaution, the dental unit (2) may not be restarted directly after the PM cycle is run.



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ANTIMICROBIAL FLUSH SYSTEM AND METHOD

DESCRIPTION

TECHNICAL FIELD:

The present invention relates generally to the field of automated medical and dental appliances, and more particularly to a system for disinfecting medical and dental unit waterlines (DUWL) which convey water to dental or medical implements or instruments for irrigation and/or cooling and to cuspidor drink cups. The predominant current usage of the antimicrobial flush system of this invention is to assist in disinfecting water lines in dental handpiece units used for dental cleaning and surgery.

BACKGROUND ART:

Modern dental handpiece units employ electricity for illumination, air for pneumatic power, and water for cooling and/or irrigation, where a dental tool contacts teeth, bone or gums, and for drinking. The water supply can be provided either from city water or from a closed deionized or sterilized water system. However, in either system, once the handpiece or cup is replaced in a cradle after use, the remaining water in the feed lines, which are generally more than three feet long, and in the feed reservoirs and handpieces, stagnates. The water rapidly becomes contaminated by microbial populations, including bacteria, fungi and protozoa. Although the handpieces can be removed and sterilized, it has not been feasible to attempt to sterilize the feed lines except by laborious manual flushing.

It has been recognized that such microbial contamination is definitely a health hazard during surgical and dental cleaning procedures, due to the fact that patients and healthcare professionals are exposed to delivery of the contaminated water directly at the site of the surgical or dental procedure.

This problem of dental unit waterline (DUWL) bacterial contamination is discussed in an article by Andrews, N., **Dental Unit Waterline Contamination**, in Practical Hygiene, July/Aug. 1994, pp. 11-20. The problem is significant, with DUWL bacterial populations frequently exceeding EPA and U.S. Army standards for potable water. Andrews concludes that flushing with water has proven unreliable at best, if any biofilm is present. Andrews also notes that biofilm is impossible to rule out. In addition to delivery of pathogens to patients and health care workers by direct contact (lavage) of open tissue, bacteria can also be communicated by aspiration of contaminated water, inhalation of aerosol and ingestion (swallowing). The patients are not the only persons at risk. The scientific evidence suggests dental clinicians receive significant long term exposure to DUWL microbes. Indeed, there are anecdotal reports of DUWL microbial exposure contributing to the deaths of several dentists.

Prior art efforts at addressing this problem have included the employment of closed water systems using sterilized water. However this is a less than suitable or long term remedy, since the environment, principally tubing, through which the water is introduced and used is not sterile, and contamination will

eventually occur. Even relatively pure city water contains some bacteria. Thus, where city water is used in the system the problem is exacerbated and accelerated. Prior to the present invention, the only way to clean dental handpiece units has been to disconnect the delivery tubes and/or handpieces involved from the feed water supply, and then go through a laborious immersion disinfection procedure (for handpieces), and/or a laborious and unreliable procedure of introduction and passage of disinfecting fluids through the tubes. According to such methods, the degree of cleansing depends upon the competence of the personnel doing the cleaning and the cleaning schedule and adherence thereto. Under the time constraints of modern dental practice, the procedure is often shortened or becomes infrequent, if not omitted entirely.

In addition to the usual dental drills, syringes and drink cups, ultrasonic scalers are in wide use in dental offices to remove calculus, old cement, tartar stains, etc. These units also employ a water flow system to keep the tip cool, flush the work area, and assist in transmission of ultrasonic frequency energy. They are employed below gum line, e.g., in cases of gingivitis, abscesses, root canal work, etc. Accordingly, microbial populations developing in the lines of these units, e.g., between periods of use (stagnation), can be delivered to open tissue.

Likewise, there are non-ultrasonic scalers and air polishing units, which use a combination of air, water and abrasive to clean and polish teeth. These also require water and airlines, which can become stagnant and in which the DUWL microbes develop.

Manual flush systems are currently available from: Forest Dental, Hillsboro, OR; Ampco Dental, Grover City, CA; Adec Dental Manufacturing, Newberg, OR; Dental Components, Inc. (DCI), Newberg, OR; and PROMA, Carson, CA, among others. Even with such manual systems, poor, inconsistent or intermitted operations result in development of a film-like coating on the insides of the lines, called a "biofilm," a consortium of microbial populations in an acellular nutrient slime matrix. Such a thick slimy film can be partially broken free from the lines with high pressure water or air and comes out of the lines as a paste. In some cases, the lines become completely plugged.

Accordingly, there is a need for a simple system that is low in cost, simple to operate, and relatively fool proof, and which can be automatically cycled at the end of or before dental procedures, and/or cycled automatically according to a regular schedule.

DISCLOSURE OF INVENTION

OBJECTS AND ADVANTAGES:

It is among the objects and advantages of the present invention to provide an antimicrobial flush system (AMB Flush System) for medical/dental instruments, particularly dental handpieces, which system is automatic and easy to operate and may be retrofitted to current dental units.

Other objects and advantages of the invention include providing: 1) an antimicrobial flush system which can be cycled at the beginning and/or at the end of every procedure; 2) an AMB Flush System which has built in safeguards to prevent misuse, and may be dedicated to service a single dental chair unit or medical station, or a single larger system can be hooked in parallel via a manifold system to a plurality

of dental chair units in one dental or medical office; 3) several alternative embodiments of an AMB Flush System for dental/medical instruments, particularly handpiece units and scalers, embodiments of which include both a pneumatic valve actuated system and an electrically controlled system; 4) an automatic AMB fluid line flush system for medical and dental handpieces, scalers and surgical tomes, which flush system can be manually initiated and/or placed on a timer such that fluid feed lines to and from a handpiece can be flushed automatically, intermittently or at will; 5) a multi step process for sterilizing the internal lines of medical/dental devices which process not only reduces contamination but also aids in preventing further microbial growth during periods of non use; 6) a system for flushing dental/medical instruments that is easy to initiate and complete, and does not depend upon the diligence or the skill of the operator; and additional objects and advantages are apparent from the following detailed description, drawing and appended claims.

The objects and advantages of the present invention are accomplished by the inventive system and method which includes means and steps for the internal sterilization of liquid lines in medical and dental instruments, particularly the water lines in dental handpiece and scaler units (herein "dental units"). The method comprises steps in one or more cycles including a PM (evening) cycle and an AM (daytime) cycle which may be employed separately or sequentially. The PM cycle steps include: Flushing the lines with a disinfectant solution for a timed period or volume; then flushing with fresh, preferably sterile, water for a timed period or volume; and finally keeping microbes from forming by flushing or evacuating the lines with a compressed gas, preferably air, or by vacuum suction, either continuously or at least until the lines are substantially dry. The AM cycle includes the steps of flushing with disinfectant, followed by rinsing with water.

Optional additional steps include repeat flushing of the lines with the disinfectant solution and then with water or other reuse media. Aspects of the method include a positive safety lock-out mode which prevents interruption of the method at steps wherein it would be undesirable to use the dental unit immediately following such step, and/or for preventing the use of the dental unit while the flush procedure is in progress, and/or to prevent disinfectant solution from reaching the patient. The method further preferably includes requiring the AM cycle to be completed at the beginning of a use period, e.g., in the morning, so as to prepare the system for use, even after a prior day's disinfecting procedure, i.e. after the PM cycle had been done the evening before.

The system apparatus has, in both a first preferred embodiment and in a first equally preferred alternate embodiment: A pneumatically initiated indicator system to identify when the system is in operation and when the dental unit is in readiness; a pneumatically controlled valve system, including safety lock-out; manifold tubing, reservoir means and drain means. The system further has a unique pneumatic timing means for controlling the sequence of operation of the system. In a second equally preferred alternate embodiment of the invention, status indication is accomplished with indicator lights and valve operation is controlled electrically by solenoid operation, with the timing and sequence of operation being controlled by electronic means. Safety interlock means insure that the system is essentially "fool proof."

Principal alternatives include a special reservoir into which the handpiece hoses are inserted, alternative valve types, alternative timing means, and alternative disinfectant solutions such as aqueous solutions of alcohol, ozone, hydrogen peroxide, organic chemical biocides (such as Betadyne) and combinations (mixtures or sequences thereof). A conventional ozone generator/infuser such as a "DELZONE" ozone generator, is available from Del Industries, San Luis Obispo, California. The water also can be disinfected using ultraviolet irridation.

Anti-microbial flush systems of this invention can be employed with scalers and polishers. Examples of units to which this invention system apparatus can be connected include: Bobcat™ Ultrasonic scaler; Cavetron™ Jet 30 combination cavetron unit and jet air (air/water/abrasive) polisher, Prophy-Jet™ 30 polisher, and Cavetron™ 3000 cavetron unit, all from Dentsply Co. of York, PA; and Autoscaler of Southeast Instruments of Miami, FL. The interconnection of the AMB Flush System of this invention to such scalers and air polishing is accomplished by adding a fitting (to U8, U9, or U10 below) and the accessory output line(s) (U3 or U5 below), and then connecting a line from the fitting to an air switch adaptor (ASA-2), and electrically connecting the air switch adaptor to the foot pedal of the scaler/polisher unit. Once the scaler/polisher unit is connected to power, and switched to the "on" position, the AM or PM buttons on the flush system of the invention will activate the scaler/polisher unit and automatically flush the unit's lines.

Thus, with such an air/electric switch air-value or solenoid, any water system can be controlled and flushed automatically by the AMB flush system of this invention. Indeed, the system of this invention is easily adapted to multi-chair, multi-dental unit operation by using simple parallel manifolding. The individual dental units can be individually activated for the flush cycle by appropriate selector valves.

Likewise, the system may be adapted for use in all cases where bacterial or microbial contamination is an interference or hazard. Examples include, but are not limited to: drinking water lines in school or public fountains, refrigerators, RV or camper vehicle or remote site potable water lines; food preparation water lines; cosmetology stations; painting; and other treatments or uses.

In an important alternative, a programmable timer is employed in conjunction with the control unit of the AMB Flush System of this invention. This timer permits the user, e.g., dental professional, to preset cleaning times so there are regular daily flush cycles. The PM cycle can be pre-programmed (preset) to start 15 minutes after close of business in the evening, and the AM cycle to start 5-15 minutes before start of business in the morning. Optionally, a midday (lunch hour) repeat of the AM cycle can be programmed. This timer preferably includes a battery backup. In addition, the entire electrical power for the AMB Flush System may be supported with a conventional gel-cell type trickle charger to supply systems operating power during power outages.

A fluid flow water or biosensar can be employed in conjunction with the AMB Flush System control unit so that the bactericide, antimicrobial flush agent or disinfectant can be metered by volume, or the microbial content digs can be assessed as a function of flushing, or a combination of both, and the disinfecting step(s) of the cycle terminated open a preset volume flow or reaching a preset low bacterial/ microbial content threshold.

BRIEF DESCRIPTION OF DRAWINGS:

The invention is illustrated in more detail in the drawings in which:

Figure 1 is an isometric schematic view of a dental chair and related apparatus showing a typical installation of the antimicrobial flush system of this invention;

Figure 2 is a schematic diagram showing relevant portions of a prior art dental unit with which the present invention can be used;

Figure 3 is a flow chart depicting a flush process of the present invention;

Figure 4 is a diagrammatic representation of a preferred embodiment of an AMB Flush System according to the present invention;

Figure 5 is a diagrammatic representation of a first equally preferred alternate embodiment of the present invention;

Figure 6 is a cross sectional plan view of a pinch valve as used in the first equally preferred alternate embodiment of the invention;

Figure 7 is a diagrammatic representation of a second equally preferred alternate embodiment of the present invention;

Figure 8 is a schematic of an electronic control portion of the second equally preferred alternate embodiment depicted in **Figure 7**; and

Figure 9 is a perspective view of a reservoir bottle employed in the system of this invention.

BEST MODE(S) FOR CARRYING OUT THE INVENTION:

The following detailed description illustrates the best mode(s) of the invention by way of example, and not by way of limitation of the principles of the invention. This description will clearly enable one skilled in the art to make and use the invention, and describes several embodiments, adaptations, variations, alternatives and uses of the invention, including what the inventor presently believes to be the best mode for carrying out the invention. In the figures discussed below the 300 series numbers refer to **Fig. 3**, the 400 series to **Fig. 4** and **5**, 500 to **Fig. 5**, 600 to **Fig. 6**, 700 to **Fig. 7**, 800 to **Fig. 8** and 900 to **Fig. 9**.

A dental delivery system is illustrated schematically in **Fig. 1**, which includes a standard dental chair **1** and a dental unit **2** appurtenant thereto. The dental unit **2** is a conventional distribution control device such as is commonly used today in dental offices for providing and controlling feed of air, light, water, and, optionally, low voltage electricity for a variety of functions, or for some more narrowly defined specific function such as abrasive cleaning. The dental unit **2** may be placed at any of a variety of locations relative to the dental chair **1**, although it is usually desirable to place the dental unit **2** within easy reach of the dentist. Alternative known locations for the dental unit **2** (not shown for clarity) include mounting on a wall, the dental (patient) chair, a cabinet or on a mobile cart. The illustrative dental unit **2** generally has a syringe **3** and at least one handpiece **4** (three are shown in the example of **Fig. 1**), although

this arrangement is not strictly required. Indeed, other dental units (not shown) may include a different quantity of handpieces (not shown) and/or other variations. A foot control **5** is conventionally provided whereby the dentist may control operation of the handpiece **4** (as well as, perhaps, other functions).

A plurality (one per handpiece **4**)of handpiece hoses **6a-6c** connect the handpieces **4** to the dental unit **2** and a syringe hose **6d** connects the syringe **3** to the dental unit **2**. The handpiece hoses **6a-6c** and the three-lumen syringe hose **6d** (air, water, drain) will generally differ in construction from each other, and such hoses may also vary somewhat in construction from application to application. These hoses generally deliver both water and air to the handpieces **4** and the syringe **3**, and the handpiece hoses also generally deliver electrical power to handpiece connectors having intensity bulbs therein for illumination, such as shown in copending Application SN08/147,750 filed 11-4-1993, now U.S. Patent 5,476,397 issued December 19, 1995. The syringe hose may also include a drain line. Standard saliva ejector **6e** and High Volume Evacuator (HVE) **6f** are also suction (drain) lines. Drink cup water is supplied through line and spigot **6g**. However, since the portions of these hoses **6a-6g** which deliver air, vacuum and/or electrical power are not discussed in detail herein, further references to these will be to the "hoses **6**," and references to "flushing" or "running solution through" the hoses **6** will refer to those portions thereof which normally deliver water (as opposed to air, vacuum or electrical power).

A conventional junction box **7** provides a terminal point for which air, water, drain (as well as connecting vacuum and electrical supply lines, and the like) can be connected to the dental unit **2**. These lines are shown schematically in **Fig. 1** by dashed lines, identified, respectively, as: Electrical "E", Water "W", Air "A", Vacuum "V" and Gravity Drain "GD." An interconnection umbilical sleeve **8** is provided for housing the various air, electrical, water, drain and vacuum supply lines from the junction box **7** to the dental unit **2**. An antimicrobial flush system control ("system control") **9** and an antimicrobial flush system indicator unit ("indicator unit") **10** are, combined, an example of the best presently known embodiment of the antimicrobial flush system (herein "AMB Flush System") of this invention **11**.

The flush system of the invention **11** can be located anywhere, but must be connected as close as possible to the water supply output, to ensure as much as possible of the chair/dental unit water system is treated, preferably all of it. Thus, although the AMB Flush System **11** may be located essentially anywhere along the interconnection hoses (or, conceivably, even at other locations), it is preferred to locate the system control **9** as near as is practical to the junction box **7** so as to treat the greatest possible portion of the hoses in the interconnection sleeve **8**. It is also preferred to locate the indicator assembly **10** integral in the housing of the dental unit **2** such that it can be readily observed by the dentist, as is indicated of **Fig. 1**. Note in **Fig. 1** the indicator assembly **10'** can be separately mounted to the side of the dental unit **2**, or elsewhere visible to the dental professional, e.g., on the post, cuspidor or light stand. However, it is not required that the AMB Flush System control **9** and the status indicator unit **10** be situated as shown in **Fig. 1**. Indeed, the system control **9** and the indicator unit **10** may be housed in a single unit comprising the AMB Flush System **11**. The invention also comprises the AMB Flush System

11 included in combination with and housed within a modified or newly manufactured dental unit 2 (not shown).

Fig. 2 is a schematic diagram of relevant portions of the dental unit 2 and junction box 7 presented in Fig. 1. The syringe 3 is fed by a three-lumen syringe hose 6d, which includes line 6d-1 for air, 6d-2 for water and 6d-3 for drain. A selector block 13 has a plurality (three in the example of Figs. 2, 13A-13C) of handpiece connectors 14 (14A-C) for connecting handpiece hoses 6a (Fig. 1) thereto, and a like plurality of selector valves 15 (15A-C) which automatically "select" the associated handpiece 4 (Fig. 1) connected to the selector block 13A, B or C for operation when that handpiece 4 (Fig. 1) is removed from the selector block 13. It should be noted that not all dental units 2 are so equipped, with some less expensive units having manual means for selection of the appropriate handpiece 4. When one of the handpieces 4 (Fig. 1) is thus selected, it is activated by the foot control 5. The syringe 3 must be drained (when the inventive AMB Flush System 10 is in operation, as will be discussed in more detail below) into a gravity drain line 6d-3 or into a cuspidor drain 16 where one is available, and/or through a vacuum line or vacuum drain (not shown). Where the drain hose 6d-3 is used, a drain valve 17 is used, and a "Y" fitting 18 may, in some applications, need to be fitted so that fluids can be diverted from the syringe 3 through the drain valve 17. A plurality of control valves and switches, generally numbered in three series 19A, B, C (six in the example of Fig. 2; valves 19A1-2 and 19B1-B3 and switch 19C), control and route water and air to the selector blocks 13A-C from the junction box 7. When the dental unit 2 is turned on by flipping switch 19C, pneumatic indicator 23 indicates the unit is "on." Thereafter, the AMB Flush System 11 may be operated by pushing power switch P, 718 (see Fig. 7).

In the junction box 7, air is input thereto through a main air valve 20 and water is input thereto through a main water valve 21. Although, as indicated in Fig. 2, water will be provided from a city water supply, one skilled in the art will recognize that a closed water supply could also be used, with appropriate adaptations for providing a separate city water supply (not shown) to the cuspidor 16. A 'tap in' point 22 is an example of where the present invention AMB Flush System 11 might tap into the existing prior art junction box 7. Line 24 is the cuspidor drain.

Fig. 3 is a flow chart depicting a general method 310 of flushing the lines and using the apparatus of the invention. According to the inventive method 310, the dental unit 2 (Fig. 1) will normally be in an operational state 311. When the user activates the master valve 415 (Fig. 4), or PV2/PV3 515 (Fig. 5) or switch P, 718 (Fig. 7) to turn on the AMB Flush System, foot control lockout valves 417 (Fig. 4), 517 Fig. 5) or 720 (Fig. 7) are closed preventing use of the dental unit 2. This is shown as "Turn On" step 312 for the AM cycle 323, and "Turn On" step 318 for the PM cycle 324. Then, when the user performs an "initiate AM" process step 313, the cycle proceeds automatically in sequence as follows: A first "flush system with solution" step 314, wherein the dental unit 2 is disinfected; then a first "flush system with water" step 315, wherein the dental unit 2 is flushed with water. The system then enters a "wait for operator intervention" hold mode 316, which enables the dental unit (DU) to be operated by the dental professional after turning off the AMB Flush System by repushing power button P, 718 (Fig. 7). Thereafter, whenever master valve

V2 **415** (**Fig. 4**), or PV2/PV3 **515** (**Fig. 5**), is closed, or switch **P718** is opened, the dental unit **2** is enabled such that it may again be operated as indicated by reinstatement of the "dental unit ready for operation "**311** status.

After AMB Flush System "Turn On" **317**, when the user pushes the PM button on the console to begin the "initiate PM" step **318**, the cycle **324** proceeds automatically, starting with a second "flush system with solution" step **319**, wherein the dental unit **2** is disinfected; then to a second "flush system with water" step **320**, wherein the dental unit **2** is flushed with water; then to a "flush system with air" step **322**, wherein the dental unit **2** is flushed with air or the water flush evacuated by vacuum draw; and finally to "wait for operator intervention" state **321**, wherein the dental unit **2** water remains "locked out" until the user performs the "initiate AM" process step **313**. When the "initiate AM" cycle **313** is initiated, the method **310** proceeds as previously related above. As can be seen in **Fig. 3**, the method **310** is logically divided into two series of operational steps: an AM cycle **323**, and a PM cycle **324**.

Fig. 4 depicts the first preferred, pneumatic embodiment **11** of the AMB Flush System of this invention employing commercially available brass/ss (stainless steel) valves. Compressed air is introduced through an air input U1 **412**, passed via an internal air tube **413** to an air regulator R2 **414** and thence to a master valve V2 **415** (shown as a toggle-type valve by way of example). When the toggle valve V2 **415** is operated (opened), air pressure is supplied simultaneously to: A) a valve V3 **416**; B) to a foot control lockout valve V13 **417** (which, as can be seen in **Fig. 4**, prevents air from being supplied from the foot control **5** when operated, thus "locking out" the operation of the handpiece(s) **4** of the dental unit **2**); C) an indicator IND-1 **418**; D) an AM actuator valve V1 **419**; E) a PM actuator valve V8 **420**; F) a signal valve V4 **421**; G) a signal valve V14 **422**; H) a signal valve V15 **423**; I) a purge air valve V10 **424**; J) a solution pressure regulator R1 **425**; and, K) through a check valve CV3 **426**, a solution and/or sterile water reservoir **427**. The solution and/or sterile water pressure regulator R1 **425** is provided merely to prevent the over pressurization of the solution and/or sterile water reservoirs **427**. Water is supplied to a water valve V7 **428** and a water valve V11 **429** from a water input **430**.

When the AM actuator valve V1 **419** is operated, air pressure is supplied, through a check valve CV8 **431** to a check valve CV1 **432** and a check valve CV2 **433**, to an expansion chamber C1 **434** and an expansion chamber C2 **435**, respectively, through Shuttle Tee ST-1 463, thereby opening a relief valve V12 **436**. Air pressure in the expansion chamber C1 **434** passes through the emergency shutoff valve V3 **416**, and opens a solution valve V6 **437** while closing the water valve V7 **428**. A precision needle valve NV1 **438** slowly bleeds air pressure from the expansion chamber C1 **434** at an adjusted, controlled rate, thereby determining how long the solution valve V6 **437** is open and the water valve V7 **428** is closed. Adjustment of the precision needle valves NV1, 2 and 3 (438, 445 and 454 in **Fig. 4**) act as a variable timer system for their respective accumulators C1 **434**, C2 **435** and C3 **449**. Air pressure in the expansion chamber C2 **435** opens the signal valve V4 **421** and closes a routing valve V9 **439**. The signal valve V4 **421**, when open, provides air pressure through an accessory port (union) U3 **440** to open the syringe drain valve V5 **17** (**Fig. 4**). The signal valve V4 **421**, when open, further provides air pressure through U3 440, and then through

check valve CV4 **442**, opening the dental unit water coolant valve to the handpieces. The signal valve U4 **421** opens one or more other accessory ports (unions) U2 **443** and U5 **444**. The accessory port U2 **443** and the accessory port U5 **444** are provided for controlling equipment external to the AMB Flush System **11**, such as a second syringe (not shown), an air electric switch (not shown) or the like. U2 **443** or U5 **444** could be used in place of U3 **440** to control CV4 **442**.

A precision needle valve NV2 **445** slowly bleeds air pressure from the expansion chamber C2 **435** at an adjusted, controlled rate, thereby determining how long the signal valve V4 **421** and the syringe drain valve V5 **17** are open, and how long the routing valve V9 **439** is closed. A standard needle valve NV4 (**Fig. 4**) slowly bleeds air pressure from the syringe drain valve V5 **17**, the check valve CV4 **442**, the accessory ports U2 **443** and U5 **444**, and an indicator IND-2 **446**.

When the PM actuator valve V8 **420** is operated, air pressure is provided, through a check valve CV5 **448**, to and through the check valve CV1 **432** and the check valve CV2 **433** to pressurize the expansion chambers C1 **434** and C2 **435**, respectively. An expansion chamber C3 **449** is also pressurized through a check valve CV6 **450**. It will be noted that, at this relative point in time, the condition of the first preferred embodiment **11** of the invention is like that previously described as existing immediately after the operation of the AM actuator valve V1 **419** except that, in addition to the expansion chamber C1 **434** and the expansion chamber C2 **435** being pressurized, the expansion chamber C3 **449** is also pressurized. Actions previously discussed herein in relation to the bleeding off of pressure from the expansion chamber C1 **434** and the expansion chamber C2 **435** also proceed, except that, when the expansion chamber C2 **435** "bleeds off" (i.e. when the pressure is sufficiently reduced therein), the routing valve V9 **439** opens. This allows the pressure in the expansion chamber C3 **449** to open the purge air valve V10 **424** and the signal valve V15 **423**, and to close the water valve V11 **429** and a PM lockout valve V16 **451**, and to "turn on" (apply pressure to) a pneumatic indicator IND-3 **452** and a pneumatic indicator IND-4 **453**. Pressure from the expansion chamber C3 **449** also opens the signal valve V14 **422**, thereby supplying air pressure through the union U3 **440** to open the syringe drain valve V5 **17** (**Fig. 4**). The pressure in the expansion chamber C3 **449** also is applied through the check valve CV4 **442** to open the water coolant valve (not shown) in the dental unit **2** (**Fig. 1**), thereby allowing air to purge the water system portion of the dental unit **2**.

A precision needle valve NV3 **454** bleeds off air pressure in the expansion chamber C3 **449**. When air pressure in the expansion chamber C3 **449** is depleted, the air valve V10 **424** closes, the signal valve V14 **422** closes, the standard needle valve NV4 **447** finishes bleeding air pressure from the internal air tubes **567**, the syringe valve V5 **17** closes, a quick exhaust QE1 **455** opens and the water coolant valve (not shown) in the dental unit **2** (**Fig. 1**) closes. The water valve V11 **429** and the PM lockout valve V16 **451** will remain closed, and the indicator IND-4 **452** will remain operated (on) until the AM actuator valve V1 **419** is manually operated. The operation of valve V1 **419**, as previously discussed herein, begins a process of flushing the dental unit **2** with a disinfectant solution **456** from the solution reservoir **427** and then flushing and refilling the appropriate system hoses with water.

In addition to the components discussed above, **Fig. 4 reveals** that a plurality of "tees" **457** (28 in the example of **Fig. 4**) and a plurality of four-way fittings **458** (4 in the example of **Fig. 4**) are used to accomplish the routings previously discussed herein.

It should further be noted regarding **Fig. 4** that, in the actual physical manifestation of the first preferred embodiment **11** of the invention, components are closely stacked and placed one upon another so as to make the unit as compact as is practical. Therefore, in order to clearly show the operation of the invention, components shown in the view of **Fig. 4** are not necessarily located as they are in the physical manifestation of the invention. Indeed, as previously noted, the lockout valve V13 **417**, the syringe drain valve V5 **17** and the quick exhaust **455** are external to the AMB Flush System **11** (**Fig. 1**) proper.

In the first preferred embodiment **11** of the present invention, the valves (using as an example, the purge air valve V10 **424**) are pneumatically operated and have an actuator portion **459** and a body **460**, which body **460** is either normally open ("NO") or normally closed ("NC") as indicated in **Fig. 4**. Also, in the first preferred embodiment **11** of the invention, the valves (e.g. **424**), as well as most of the other components are made of brass. However, these factors are a matter of choice, depending upon cost considerations, and the like, rather than specifically on functionality. One skilled in the art will recognize that valves may be made of any of a number of materials, and that there are a variety of general valve constructions on the market, any combination of which can be used with success in accomplishing the present invention, provided that necessary considerations such as relate to hygiene and durability are met.

A plurality (three in the example of **Fig. 4**) of output fittings (U8 through U10) **461** provide the output from AMB Flush System **11** to the dental unit **2** (**Fig. 1**) as well as or in addition to any other equipment (not shown) which might be connected to it for disinfection and cleaning.

Fig. 5 is a first equally preferred alternate embodiment **511** of the AMB Flush System of this invention. The first equally preferred alternate embodiment **511** of the invention is, in many respects, similar to the first preferred embodiment **11** previously described herein. References in **Fig. 5** to "PV" are abbreviations for "Pinch Valve."

Referring to **Fig. 5**, in the first equally preferred alternate embodiment **511** of the present invention, the lockout valve PV13 **517**, the indicator IND-1 **418**, the signal valve PV4 **521**, the signal valve PV14 **522**, the solution reservoir **427**, the water valve PV11 **529**, the water input U11 **430**, the expansion chamber C1 **434**, the expansion chamber C2 **435**, the syringe drain valve PV5 **540**, the routing valve PV9 **539**, the pinch valve PV4 **542**, the accessory port U5 **444**, the expansion chamber C3 **449**, the indicator IND-3 **452**, the indicator IND-4 **453**, the disinfectant solution **456**, and the output fittings **461** (**Figs. 4 and 5**) are alike in logical placement and function to those same referenced components as found in the first preferred embodiment **11**. In the first equally preferred alternate embodiment **511** of **Fig. 5**, some components and/or valves are optionally constructed of different materials or manner as is discussed below. A first dual valve V6/V7 **527** performs the functions formerly described in relation to both the water valve V7 **428** and the solution valve V6 **437** of the first preferred embodiment **11**. Construction of the dual pinch valve

527 (as well as other such valves to be introduced hereinafter) will be discussed in more detail in relation to Fig. 7.

A plurality (three in the example of Fig. 5) of pinch type "timer delay" bleed off valves 545, 547 and 554 serve the same purpose in the first equally preferred alternate embodiment 511 of the invention (that being the timed slow "bleed off" of the expansion chambers 434, 435 and 449 respectively) as do the precision needle valves 445, 447 and 454 in the first preferred embodiment 11. The bleed off pinch valves 545, 547 and 554 function merely by pinching off a hose by a controlled amount. It is known in the art and practiced in the first preferred alternate embodiment 511 of this invention to run a string (not shown) through a hose where it is to be pinched off in this manner, so as to prevent the hose from closing entirely. The bleed off pinch valves 545, 547 and 554 and the needle valves 445, 447 and 454 are functionally interchangeable. Pinch valve 566 bleeds pressure away from valve 542 and syringe drain valve 540.

In the first equally preferred alternate embodiment 511 of the invention, compressed air is introduced through an air input U1 412, passed via an internal air tube 413 to an air regulator R2 514 and therefrom to a master toggle valve PV2/PV3 515 and to an increased flow pinch valve M 516. Although increased flow valve M 516 appears redundant, it has been found that the particular type of valves used in the first preferred alternate embodiment 511 of the invention require, for their best operation, an air flow somewhat greater than is delivered through the master toggle valve V2/V3 515. Furthermore, it is desirable to optimize the air flow for individual aspects of the application by providing increased air flow by means of the increased flow pinch valve M 516, as shown in Fig. 5. Therefore, the master toggle valve PV2/V3 515 is used as a master controller with the increased flow pinch valve M 516 actually delivering controlling air flow, with an increased size of internal air tube(s) 513 as may be appropriate to the particular valve and components used in the application.

When the master toggle valve PV2/V3 515 is operated, air pressure is supplied from the increased flow pinch valve M 516 to the indicator IND-1 418, to a solution pressure regulator R1 525 and, through a check valve CV3 526 to the solution reservoir 427, to a purge air valve PV10 524, to a signal valve PV15 523, and to a combination valve PV17 528. The combination valve PV17 528 is a simple pinch valve capable of opening and/or closing a relatively large number of hoses simultaneously. The combination valve V17 528 used in the first equally preferred alternate embodiment 511 of the invention is a device well known in the art available from Proma Dental Manufacturing of Carson, CA.

When a start switch PV1 543 is momentarily operated, the combination valve PV17 528 is opened such that the first expansion chamber C1 434 and the second expansion chamber C2 435 are pressurized, and operations relating thereto are begun as previously described in relation to the first preferred embodiment 11 of the invention.

AM/PM selector pinch valve 530 is toggled such that it is in PM position 531 (that is, such that a PM air line 532 is open there through). Then momentary operation of the start switch PV1 543 causes the combination valve PV17 528 to be opened such that the first expansion chamber C1 434, the second expansion chamber C2 435 and the third expansion chamber C3 449 become pressurized, and operations

relating thereto are initiated as previously described above. Pneumatic lock out valve PV 18 **551** prevents actuation of combination valve **528** a second time when **530** is in the PM position, and C3 **449** begins to bleed off. Both lock out valves **451** and **551** are actuated by bleed-off of chamber C3 **449**.

As in the first preferred embodiment **11** of the invention, a plurality of tees **457** and four way fittings **458** are employed in this embodiment **511**, as shown in **Fig. 5**. The expansion chambers C1 **434**, C2 **435**, and C3 **449** are preferably made of plastic, but may also be made of metal such as stainless steel, brass or aluminum.

Valves preferably employed embodiment **511** are taught in Betush U.S. Patents Nos. 5,026,020 and 5,097,868 of Proma Dental, the disclosures of which are incorporated by reference herein to the extent required for full and complete disclosure. It will be noted that these referenced patents disclose normally closed valves. However, these valves may be modified to be normally open valves. **Fig. 6** is a cross sectional plan view of a typical pinch valve **610** such as is disclosed in the Betush '020 Patent referenced above. Pinch valve **610** has an actuator tube **612**, an object tube **614** which is to be opened and closed (pinched off) as required, a housing **616**, and a pinch mechanism **618** for acting upon the object tube **614** when the actuator tube **612** is inflated as described in the Betush '020 Patent. **Fig. 6** shows an uninflated actuator tube **612** and tube **614** is closed (pinched off). When tube **612** is inflated, tube **614** opens. More than one object hose **614** may be acted on in a single pinch valve **610** by placing two or more object hoses **614, 614A** side by side therein (one on top of the other as seen in **Fig. 6**). Thus, a second object hose is routed, as shown in **Fig. 6**, through an exit hole **620**, such that the second object hose **614A** is open when the actuator tube **612** is not inflated, and **614a** is closed when the actuator tube **612** is inflated. As can be understood in light of the above discussion, the pinch valve **610** may, by varying the routing of the object tubes **614** and **614A** be made to be a dual normally closed valve, a dual normally open valve, or, as in **Fig. 6**, a combination normally open/normally closed valve. Note for example alternate entry **621** for hose **614**, Thus, the various valves discussed above in relation to the alternate embodiment **511** of the present invention are of the NC, NO or combination of pinch valve type described.

Fig. 7 is a second, equally preferred, alternate embodiment **711** of the AMB Flush System of the invention. This embodiment **711** differs from the first and alternate embodiments **11** and **511** in that the timing and sequence control is accomplished by electronic means rather then by pneumatic means in embodiment **711**. Solenoid valves (designated "SV") in the following description correspond generally by number to valves (designated "V" or "PV") in the previous descriptions and functions thereof are easily understood by comparison thereto.

In the embodiment **711**, compressed air is introduced through an air input U1 **712** and provided, via an internal air tube **713** to a solenoid valve SV8 **714**. When the solenoid valve SV8 **714** is operated, air is provided to an air regulator REG 1 **715**, and then to an air regulator REG 2 **716**, through a check valve CV1 **717** and thence to a solution reservoir **427**.

When electrical power is applied to embodiment **711** via a system power switch P, **718**, a light emitting diode ("LED") L1 **719** will illuminate. The master solenoid valve SV8 **714** will operate (open) and

a foot control lockout solenoid SV12 **720** will operate (close), thereby preventing the use of the dental handpieces **4** (**Fig. 1**). When the master solenoid valve SV8 **714** is operated, air is also supplied through the regulator R1 **715** to an air signal solenoid SV9 **721** and to an air purge solenoid SV10 **722**.

When AM switch **723** is operated, an LED L2 **735** lights, syringe drain solenoid SV5 **724** opens, and the solenoid SV9 **721** opens, thereby opening a water coolant supply valve **725**, which is physically located in and a part of the dental unit **2** (**Fig. 1**), by means of an air signal supplied through a check valve CV4 **726**. Air provided through the check valve CV4 is further supplied to an accessory air switch, which is merely a switched air resource optionally provided for controlling any accessory devices which require such control. Water is provided to the dental unit **2** (**Fig. 1**) through a water solenoid SV11 **728**. When the AM switch **723** is operated, the solenoid SV7 closes, thereby shutting off the normal supply of water to the dental unit **2** (**Fig. 1**), and a solution solenoid SV6 **729** opens releasing the disinfectant solution **456** through a unit water output **730** into and through the interconnection hose **8** (**Fig. 1**). After a first preset time period (timing will be discussed in more detail below), the solution solenoid SV6 **729** closes and the water solenoid SV7 **728A** opens, thereby flushing the interconnection hose **8** and the dental unit **2** (**Fig. 1**) with water.

After a second predetermined time, the air signal solenoid SV9 **721** and the syringe drain solenoid SV5 **724** close and the LED L2 735 is turned off. When the user turns off the master switch P **718**, the dental unit **2** (**Fig. 1**) will be ready for use.

Pressing a PM switch **731** initially causes all of the operations discussed above in relation to the operation of the AM switch **723**. In addition, after the water solenoid valve SV7 **728A** has flushed the dental unit **2** (**Fig. 1**) with water for the second predetermined time, the water solenoid SV11 **728** again closes off the water supply, an LED L3 **732** and LED L4 **734** illuminates, and the solenoid SV10 **722** opens thereby purging the dental unit **2** (**Fig. 1**) and the interconnection hose **8** with air for a third predetermined time. Thereafter, the solenoid SV10 **722** closes (shutting off purge air) and the LED L3 **732** is turned off. The water solenoid SV11 **728** is a magnetically latching solenoid which will remain closed (thereby preventing the entry of water into the dental unit **2** (**Fig. 1**), and the LED L4 **734** will remain on until the AM switch **723** is depressed, thereby flushing the dental unit as previously discussed above.

It will be noted that operation of the dental unit **2** cannot immediately follow the series of operations following the operation of the PM switch **731** (step **318** in **Fig. 3**). Refer again to the above discussion of **Fig. 3**. Rather, operation of the AM switch **723** (step **313** in **Fig. 3**, and the following automated functions, as discussed above in **Fig. 3**) must follow the operation of the PM switch **731**. The AM switch **723** may, however, be operated whenever required without an intervening operation of the PM switch **731**. In embodiment **711**, stainless steel is used extensively in the component structure, although, as discussed above with embodiments **11** and **511**, other materials, such as plastic, can be employed for many of the components.

Fig. 7 shows an embodiment in which value unit **709** is physically distinct from an electronics unit **710**. This is analogous to the optional separation of the system control **9** from the indicator unit **10**

discussed above in relation to **Fig. 1**. A power transformer **704** provides 24V AC power to the electronics unit **710**. When power switch P, **718** is activated by the user, the air lockout solenoid SV12 **720** is actuated to lock out operation of the handpieces **4** by the foot control **5** (**Fig. 1**).

Fig. 8 is an electrical schematic of the embodiment **711**. In **Fig. 8**, embodiment **711** includes in the circuit combination shown: a dual timer **835** (type 556); a single timer **836** (type 555); a bilateral switch **837** (type LM4066); four field effect transistors ("FET's") **838** (type IRF510 MOSFET), designated **838a** through **838d**; nine diodes **839A-J** (type 1N4001); a bridge rectifier **840**; a plurality (types and quantities discussed below of resistors **841A-J**; and a plurality (types and quantities discussed below) of capacitors **842A-I**. Power is provided from the power transformer **734** (**Fig. 7**) through a power jack **843** and is switched to the bridge rectifier **840** by the power switch P **718**. When contact is made through the power switch P **718**, direct current voltage is filtered by first and second capacitors **842a** and **842b** in parallel, and provided to a voltage regulator **844**. The output of the voltage regulator **844** is controlled by a first fixed resistor **841a** and a first variable resistor **841b**. When there is output from the voltage regulator **844**, the LED L1 **719** is lit and the solenoid SV12 **720** is operated to "lock out" operation of the dental unit **2** (**Fig. 1**). A second fixed resistor **841c** limits current through the LED L1 **719**. When the AM Switch **723** is operated, the dual timer **835** and single timer **836** are each reset to zero. Then the latching bilateral switch 837 is opened so only the dual timer **835** is triggered to start counting. When the PM switch **731** is operated the same applies as in the AM procedure, except the single timer **836** also starts counting. These differential counting functions result from the circuit logic arising from the location of a first diode **839a** with respect to the AM switch **723** and a second diode **839b** with respect to the PM switch **731**. A first time period is set by a fourth capacitor **842d**, a fifth capacitor **842e**, and a second variable resistor **841d**. A second time period is set by a sixth capacitor **842f**, a seventh capacitor **842g**, and a third variable resistor **841e**. A third time period id set by an eighth capacitor **842h**, a ninth capacitor **842i**, and a fourth variable resistor **841f**. The above reset and timing operations are in accordance with the normal usage, and the published instructions for use, of the dual timer **835** and the single timer **836**.

During the first time period, the first FET **838a** is biased into conduction such that the solution solenoid SV6 **729** and the water solenoid SV7 **728** are operated. The LED L2 **735** is lit, with current through it being limited by a fourth fixed resistor **841g**. A third diode **839c** and a fourth diode **839d** are provided as shown in **Fig. 8** to prevent reverse current surges during operation of the solenoids **729** and **728** respectively.

During the second time period, the second FET **838b** is biased into conduction such that the syringe drain solenoid SV5 **724** and the air signal solenoid SV9 **721** are operated. The LED L3 **732** is lit, with current through it being limited by a fifth fixed resistor **841h**. A fifth diode **839e** and a sixth diode **839f** are provided as shown in **Fig. 8** to prevent reverse current surges during operation of the solenoids **724** and **721**.

During the third time period, the third FET **838c** is biased into conduction such that the air purge solenoid SV10 **722** and the water lockout solenoid SV11 **728** are operated. The LED L4 **734** is lit, with

current through it being limited by a sixth fixed resistor **841i**. A seventh diode **839g** and an eighth diode **839h** are provided as shown in **Fig. 8** to prevent reverse current surges during operation of the solenoids **728** and **722**.

When the third FET **838c** is initially biased into conduction by the single timer **836**, the fourth FET **838d** is also biased into conduction and the bilateral switch **837** is triggered to on through a ninth diode **839j**. Therefore, even after the third time has expired and the third FET **838c** has stopped conducting, the solenoids SV10 **722** and SV11 **728** will remain operated and the LED L4 **733** will remain lit until the AM switch P **723** is engaged by the operator. A seventh fixed resistor **841j** biases the bilateral switch **837**. An emergency reset switch E **845** resets the dual timer **835** and the single timer **836**. If the E Switch **845** is pressed, the AM procedure will then have to be initiated before the dental unit will reactivate.

The resistors **841** are of the values shown in the schematic of **Fig. 8** and listed here:

841a 240 Ω	**841d** 10 KΩ variable	**841g** 620 Ω	**841l** 620 Ω
841b 5 KΩ variable	**841e** 10 KΩ variable	**841h** 620 Ω	**841j** 2MΩ
841c 620 Ω	**841f** 10 KΩ variable		

The capacitors **842** are of the values shown in the schematic of **Fig. 8** and listed here:

842a 220 μf	**842d** 100 μf	**842g** 100 μf
842b 100 μf	**842e** .01 μf	**842h** .01 μf
842c 1.0 μf	**842f** .01 μf	**842l** 100 μf

An automatic timer **846** is provided as a preferred option. A multiplug **847**, or in the case of pneumatic operation a 3-position disconnect, attaches to the (AMB) control **711**, providing operator presettable times for activation of the AM and PM Modes **323** and **324**. By pushing timer clock set **898**, and either the AM set button **849** or the PM set button **850**, the clock **851** can be advanced by hitting "+" button **852** or retarded by hitting "-" button **853**. The appropriate LED **854** for AM or PM lights to show which mode the controller is in. A battery backup **855** is included. Multiple cycles can be set for a given period, e.g. per day, per week or indefinitely. Factory preset default modes, e.g. a minimum number of cycles at a preset time, say 10 PM and 7 AM may be included in a clock memory. This timer may also include a volume flow control meter as an alternative or additional control feature. A battery backup **855** is provided in case of a power failure, so the preset times are kept intact. There are two versions of the timer: electronic and pneumatic.

A system battery backup **856**, typically a gel-cell battery kept at full charge via a trickle charger, is a preferred option to power the entire AMB Flush System operation in case of power failure.

Fig. 9 is an exploded isometric view of a reservoir bottle **910** such as is optionally used with the AMB Flush System **10** of the invention. A reservoir cap **911** screws onto the reservoir bottle **910** by the union of a cap threading **912** and a bottle threading **913** in the manner of conventional "screw on" type bottle caps (not shown). A plurality (four in the example of **Fig. 9**) of hose receptor recesses **914** are adapted for receiving (one each per hose) an end of the handpiece hoses **6a** after the handpiece **4** (**Fig. 1**) has previously been removed therefrom, such that fluids may pass through the handpiece hose **6a** into

the reservoir bottle **910**. An annular stop lip **915** at the bottom of each of the hose receptor recesses **914** stops the handpiece hose **4** from passing into the reservoir bottle **910**.

As can be appreciated in light of the above discussion, all three embodiments **11**, **511** and **711** of the invention have two cycles: A PM series **324** and an AM series **323** (**Fig. 3**). The AM series may be performed at any time that the dental unit **2** (**Fig. 1**) is not in operation, and the dental unit **2** may be used immediately thereafter. The PM series **324** leaves the hoses **6** and **8** "air dried" to prevent microbial growth when the dental unit **2** is not to be used for an extended period of time, such as in the evening, overnight, vacations, weekends, off days (closed hours) or long waiting periods between procedures. In this regard it has been discovered that air drying the hoses **6** and **8** is a very important in preventing the growth of biofilm and/or microbes in the dental unit **2** and related hoses **6** and **8**. Further, in accord and with the best presently known embodiment of the inventive method **310**, the dental unit **2** cannot be used immediately following the PM series **324**. Rather, the AM series **323** must be run following the PM series **323** to insure a reflushing after the longer period of non-use. The dental unit **2** is further made inoperative during either the AM series **323** or the PM series **324** of operational steps. The overall programmable system timer **856** (**Fig. 8**) can be employed to initiate the PM cycle, say at the end of each working day, so the operation of the AMB Flush System is completely automatic. Likewise, a conventional "low reservoir" fluid level sensor system **740** (**Fig. 7**) may be placed into the reservoir **427** to initiate a "low" or "full reservoir" LED and/or pizeoannunciator **742** on the control console **2**, **10**, **511**, or **711** as desired. This can be connected via a MOSFET switch to interrupt the AMB power so the unit will not operate with inadequate disinfectant supply.

In any of the present embodiments **11**, **511** and **711** of the invention, the indicators IND-1 **418** and/or the LED L1 **719** indicate that the respective embodiment is "on." The indicators IND-2 **446** and/or LED L2 **735** indicate that the AM series **323** (**Fig. 1**) is being performed. The indicators IND-3 **452** and/or the LED L-3 **732** indicate that the PM series **324** is being performed. The indicators IND-4 **453** and/or the LED-4 **734** indicate that the dental unit **2** water supply is locked out."

Although all of the time periods involved in the inventive method **310** are variable as discussed in relation to the various present embodiments **11**, **511** and **711**, it is currently believed that 3 minute periods are generally adequate for each of the "flush system with solution" steps **314** and **319** and the "flush system with water" steps **315** and **320**. While no optimal time for the flush system with air step **321** has yet been determined, it is thought that approximately 15 minutes should be sufficient, although a longer time period would be optimal.

Any of a number of disinfectant, antimicrobial, or sterilizing fluids may be used as the disinfectant solution **456**, although it is currently accepted in the field that a 10% solution of commercially available Clorox® bleach is appropriate for such purposes. (Note that commercial grade Clorox® bleach contains 5.5% sodium hypochlorite solution, and so the appropriate concentration of sodium hypochlorite is approximately 0.05%.) Other solutions include alcohol, peroxide, ozone, betadyne and the like, aqueous disinfectant solutions, or a combination thereof.

Although there is substantial tolerance for variance, in the present embodiments **11**, **511** and **711** of the invention, supply air pressures are approximately 70 pounds per square inch ("psi"), with regulated air pressure therein being reduced to approximately 50 psi. Air pressure supplied to the solution reservoir **456** further reduced to approximately 35 psi, since the plastic solution reservoir **456** cannot withstand the much greater pressures.

INDUSTRIAL APPLICABILITY:

It is evident that the system apparatus and methods of the invention have wide industrial, commercial and clinical applicability to water line treatment. Although the present invention has been described herein as being useful primarily with dental equipment, it is equally useful for use with general medical equipment or in any application wherein it is desirable or necessary to keep fluid delivery lines free of microbial growth during periods of low or non-use including water fountains, refillable bottle water dispensing stations, plumbed coffee and soft drink makers and the like. The AMB Flush Systems **11**, **511**, **711** of the present invention may be utilized in essentially any application wherein conventional dental units **2** are used. Since the AMB Flush System **11**, **511**, **711** of the present invention may be readily constructed are readily compatible with existing hardware, as a retrofit or integrated into a new dental unit design, it provides an important new means and method for preventing dangerous microbial growth, particularly in dental and medical equipment. It is evident that the utility and medical applicability of the invention will be both significant in scope and long-lasting in duration.

It should be understood that various modifications within the scope of this invention can be made by one of ordinary skill in the art without departing from the spirit thereof. I therefore wish my invention to be defined by the scope of the appended claims as broadly as the prior art will permit, and in view of the specification if need be.

CLAIMS

1. A method for inhibiting growth of microbes in one or more fluid delivery lines to a device at least one of which lines provides water or a water solution comprising the steps of:

a) flushing said at least one fluid delivery line with a disinfectant solution for a time period sufficient to effect antimicrobial action;

b) flushing said fluid delivery line with a compressed gas or evacuating it with a vacuum for a predetermined time;

c) again flushing said fluid delivery line for a predetermined time with a disinfectant solution;

d) rinsing said disinfectant solution from said fluid delivery line for a predetermined time; and

e) causing said steps a and b to proceed automatically when step a is initiated, and steps c and d to proceed automatically when step c is initiated.

2. A method as in claim 1 which includes the steps of flushing said fluid delivery line with water for a predetermined time after step a and before step b.

3. A method as in claim 1 wherein in step b said fluid delivery line is flushed with a gas or evacuated with vacuum for time sufficient to substantially dry said fluid delivery line.

4. A method as in claim 3 wherein in step b, after flushing said delivery line with a gas, said line is maintained open to atmosphere until step c is initiated.

5. A method as in claim 1 which includes the step of disabling the device employing said fluid delivery line such that it will not function immediately following step a, step b, or step c, without first completing step d.

6. A method as in claim 1 which includes the step of disabling the device employing such fluid delivery line such that it will not function during steps a - d.

7. A method as in claim 1 wherein said gas is air and said rinsing employs water as a rinsing medium.

8. A method as in claim 1 wherein after step b has begun, the method is prevented from being restarted without first completing steps c and d.

9. A method as in claim 2 which includes the step of disabling the device employing said fluid delivery line such that it will not function during steps a - d.

10. A method as in claim 1 wherein said device is a dental handpiece unit.

11. An antimicrobial flushing apparatus for disinfecting at least one fluid transfer hose to a device which hose provides water or a water solution, comprising in operative combination:

a) a solution reservoir for holding a disinfecting solution;

b) solution delivery means for delivering a disinfecting solution from said solution reservoir to and through said hose;

c) purge delivery means for purging said hose with a compressed gas or vacuum;

d) water delivery means for purging said hose with flush water;

e) means for automated sequencing operation of said solution delivery means, said purge delivery means and said water delivery means; and

f) means for timing delivery of said solution, gas or vacuum, and flush water.

12. An antimicrobial flushing apparatus as in claim 11 wherein said automated sequencing means includes a first user control means for initiating said sequencing means to cause said solution delivery means to deliver the disinfecting solution through said hose for a first preset time, after which first preset time said timing means causes said gas or vacuum purge delivery means to purge said hoses with compressed gas or vacuum.

13. An antimicrobial flushing apparatus as in claim 11 wherein said timing means includes means for maintaining said hose open to atmosphere after said timing means has caused said purge delivery means to purge said hose with compressed gas or vacuum.

14. An antimicrobial flushing apparatus as in claim 11 wherein said automated sequencing means includes a user control means for initiating said timing means to cause said solution delivery means to deliver said disinfecting solution through said hose for a preset time, after which said preset time, said timing means causes said water delivery means to purge said hose with water.

15. An antimicrobial flushing apparatus as in claim 11 wherein said reservoir includes a disinfecting solution selected from an aqueous solution of ethyl alcohol, ozone, hydrogen peroxide, an organic biolide, and combinations or sequences thereof.

16. An antimicrobial flushing apparatus as in claim 11 which includes means for selectively programming the initiation of operation of said sequencing and timing means to operate at selected preset times.

17. An antimicrobial flushing apparatus as in claim 12 wherein said automated sequencing means includes a second user control means for initiating said timing means to cause said solution delivery means to deliver said disinfecting solution through said hose for a second preset time, after which said second preset time, said timing means causes said water delivery means to purge said hose with water.

18. An antimicrobial flushing apparatus as in claim 17 wherein said timing means includes means for maintaining said hose open to atmosphere after said timing means has caused said purge delivery means to purge said hose with compressed gas or vacuum.

19. An antimicrobial flushing apparatus as in claim 11 wherein said sequencing and timing means includes valve units selected from pneumatic type valves, pinch type valves, solenoid type valves, or combinations of said types of valves.

20. A circuit for sequencing and timing an antimicrobial flush system comprising in operative combination the elements depicted in and functionally interconnected as in Figure 8.

21. An improved pinch valve comprising in operative combination:

a) a housing having at least one internal stop;

b) means for pinching a tube closed against said stop disposed in said housing;

c) at least one inlet in said housing;

d) at least one outlet in said housing;

e) means for actuating said pinch mechanism; and

f) said inlet, outlet, stop and pinch mechanism are arranged relative to each other in said housing with multiple tubings routed through said inlet and said outlet in contact with said pinch mechanism and said stop so that said pinch mechanism may operate, upon actuation, to normally close or to normally open one or more of said tubings, or biacts to normally close at least one tube while simultaneously normally opening at least one other of said tubes.

22. A pinch valve as in claim **22** wherein:

a) there is at least one inlet;

b) there are at least two outlets;

c) there are at least two stops;

d) at least two tubes may be threaded from said inlets to said outlets, each adjacent a different one of said stops; and

e) said pinch mechanism biacts so that one tube is pinched closed when the other is open.

23. A pinch valve as in claim 22, wherein said actuating means is pneumatic.

24. A method for inhibiting growth of microbes in one or more fluid delivery lines to a device, at least one of which lines provides water or a water solution comprising the steps of:

a) flushing said at least one fluid delivery line with a disinfectant solution for a time sufficient to effect microbial growth suppression;

b) flushing said disinfectant solution from said line with a rinse medium for a time sufficient to reduce said disinfectant to a non-harmful level; and

c) as a cycle, upon initiation of step a, both said steps a) and b) proceed automatically to completion.

25. A method as in claim 24 which includes the step of locking out said device so that its operation may not be commenced once step a is initiated until after step b is completed.

26. A method as in claim 25 which includes the step of programming the initiation of operation of said flushing steps to operate at selected preset times.

27. A method as in claim 26 wherein said programming step includes controlling said sequencing and timing means to open and close valve units selected from pneumatic type valves, pinch type valves, solenoid type valves, or combinations of said types of valves.

28. A method for inhibiting growth of microbes in one or more fluid delivery lines to a device, at least one of which lines provides water or a water solution comprising the steps of:

a) flushing at least one fluid delivery line with a disinfectant solution for a time sufficient to effect microbial growth suppression;

b) flushing said disinfectant solution from said line with a rinse medium for a time sufficient to reduce said disinfectant to a non-harmful level; and

c) removing said rinse medium from said line by compressed gas or a vacuum for a time to substantially dry said line; and

d) as a cycle, upon initiation of step a, said steps a), b) and c) proceed automatically to completion.

29. A method as in claim 26 which includes the step of locking out said device so that its operation may not be commenced once step a) is initiated until after step c) is completed.

30. A method as in claim 29 which includes the steps of programming the initiation of operation of said flushing steps to operate at selected preset times.

31. A method as in claim 29 wherein said programming step includes controlling sequencing and timing means to open and close valve units selected from pneumatic type valves, pinch type valves, solenoid type valves, or combinations of said types of valves.

32. A method as in claim 28 wherein said gas is air, said rinse medium is water and said disinfectant solution is selected from an aqueous solution of ethyl alcohol, ozone, hydrogen peroxide, an organic biolide, and combinations or sequences thereof.

33. A method as in claim 31 wherein said gas is air, said rinse medium is water and said disinfectant solution is selected from an aqueous solution of ethyl alcohol, ozone, hydrogen peroxide, an organic biolide, and combinations or sequences thereof.

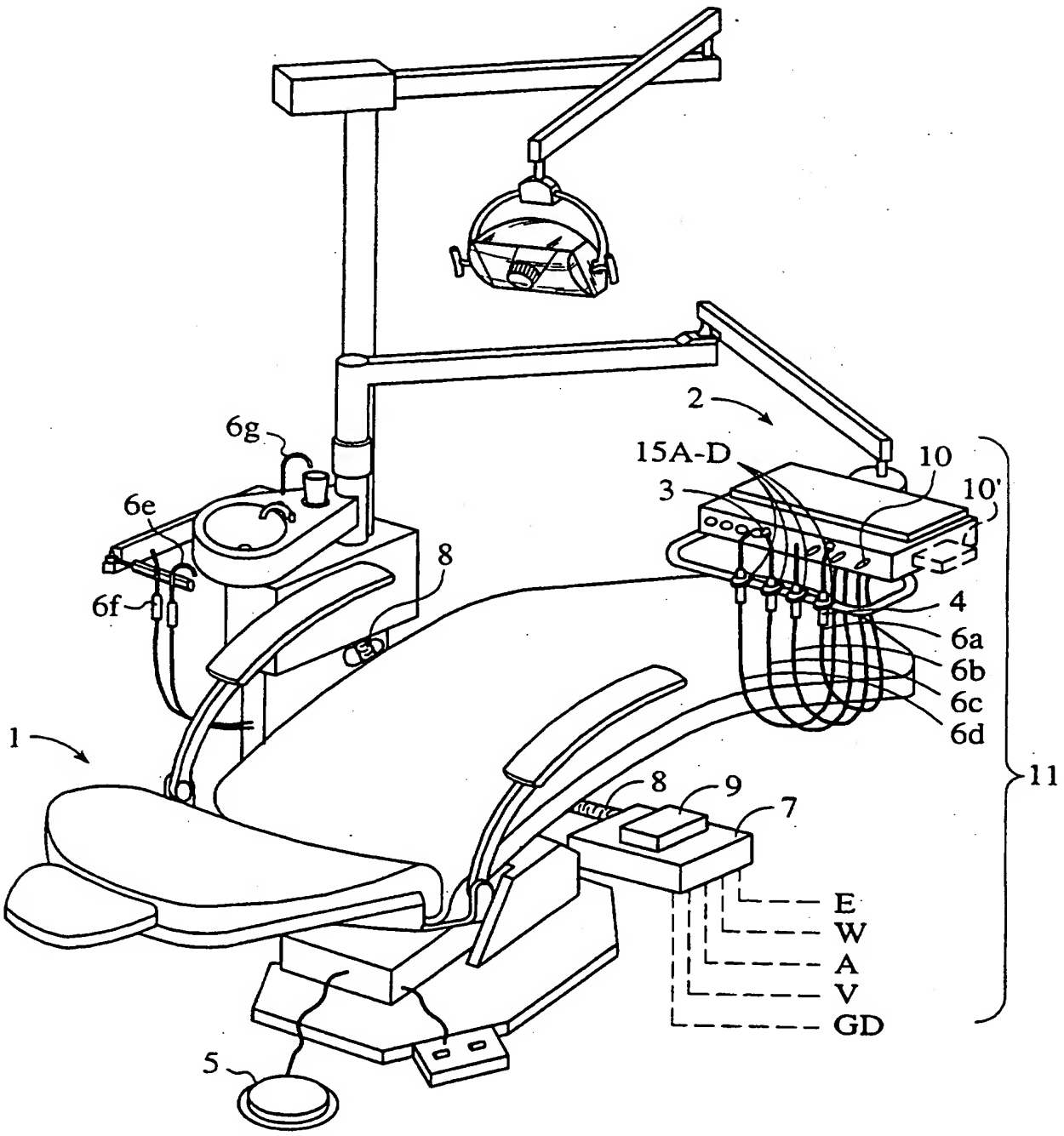
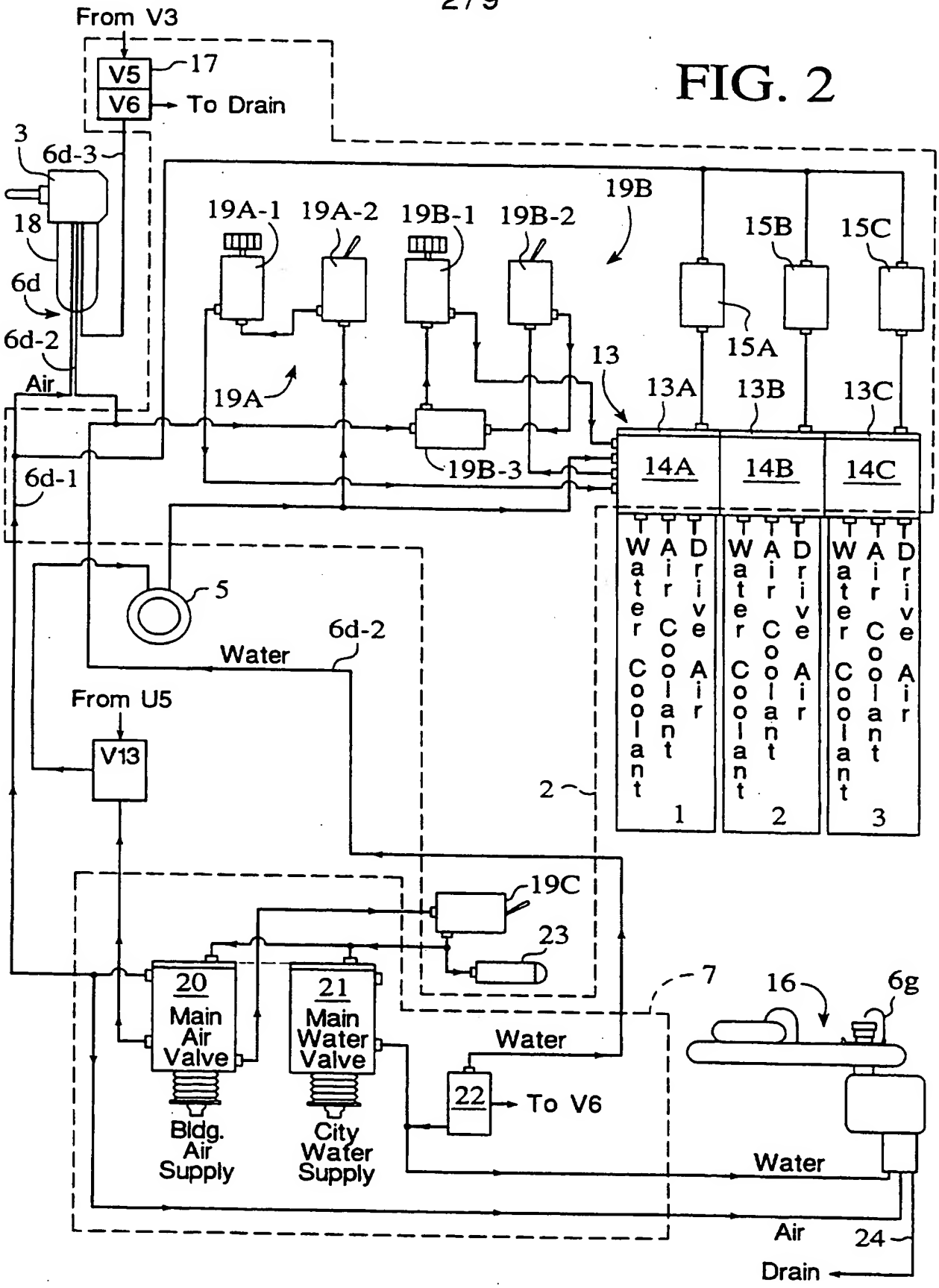
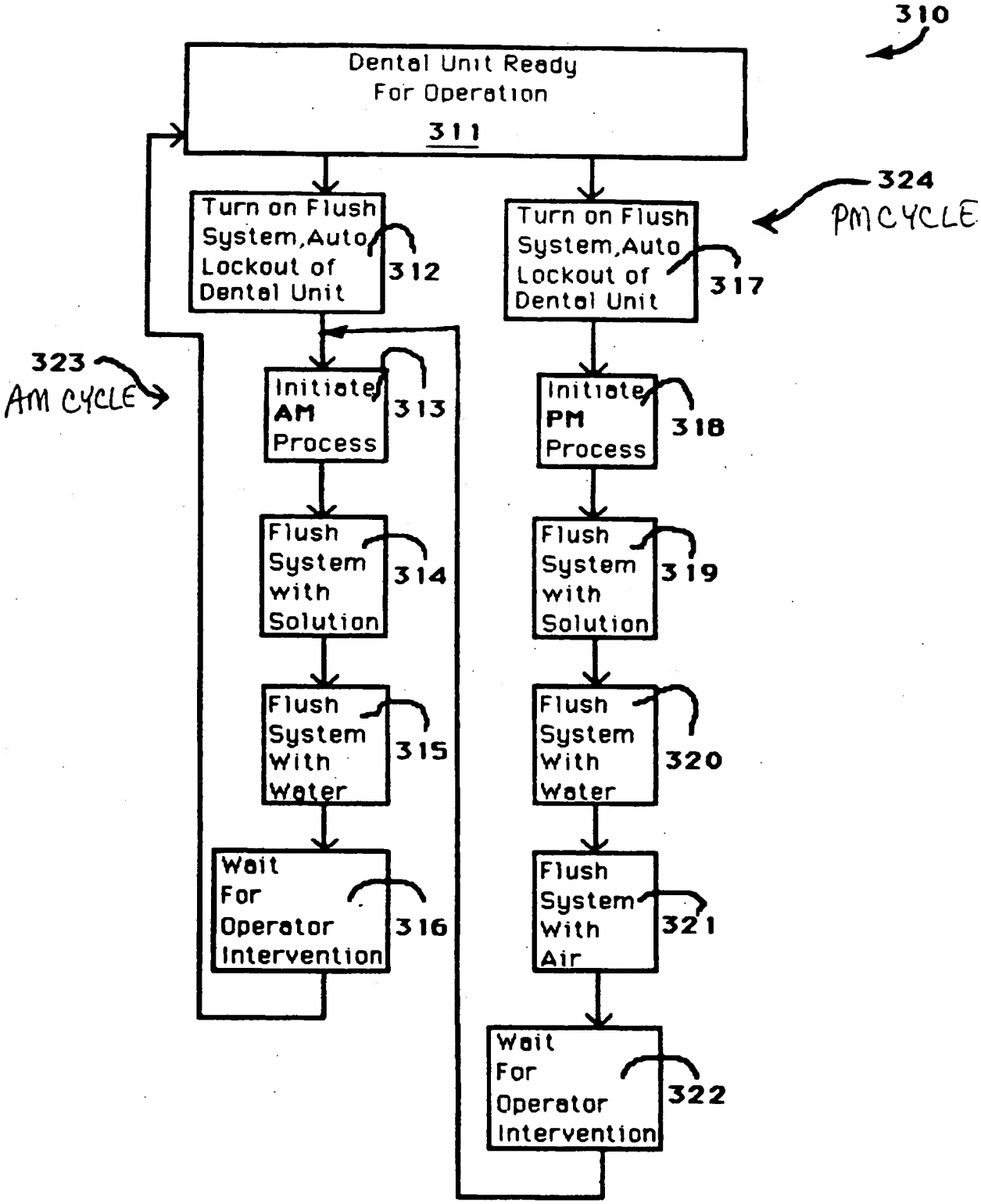


FIG. 1

FIG. 2





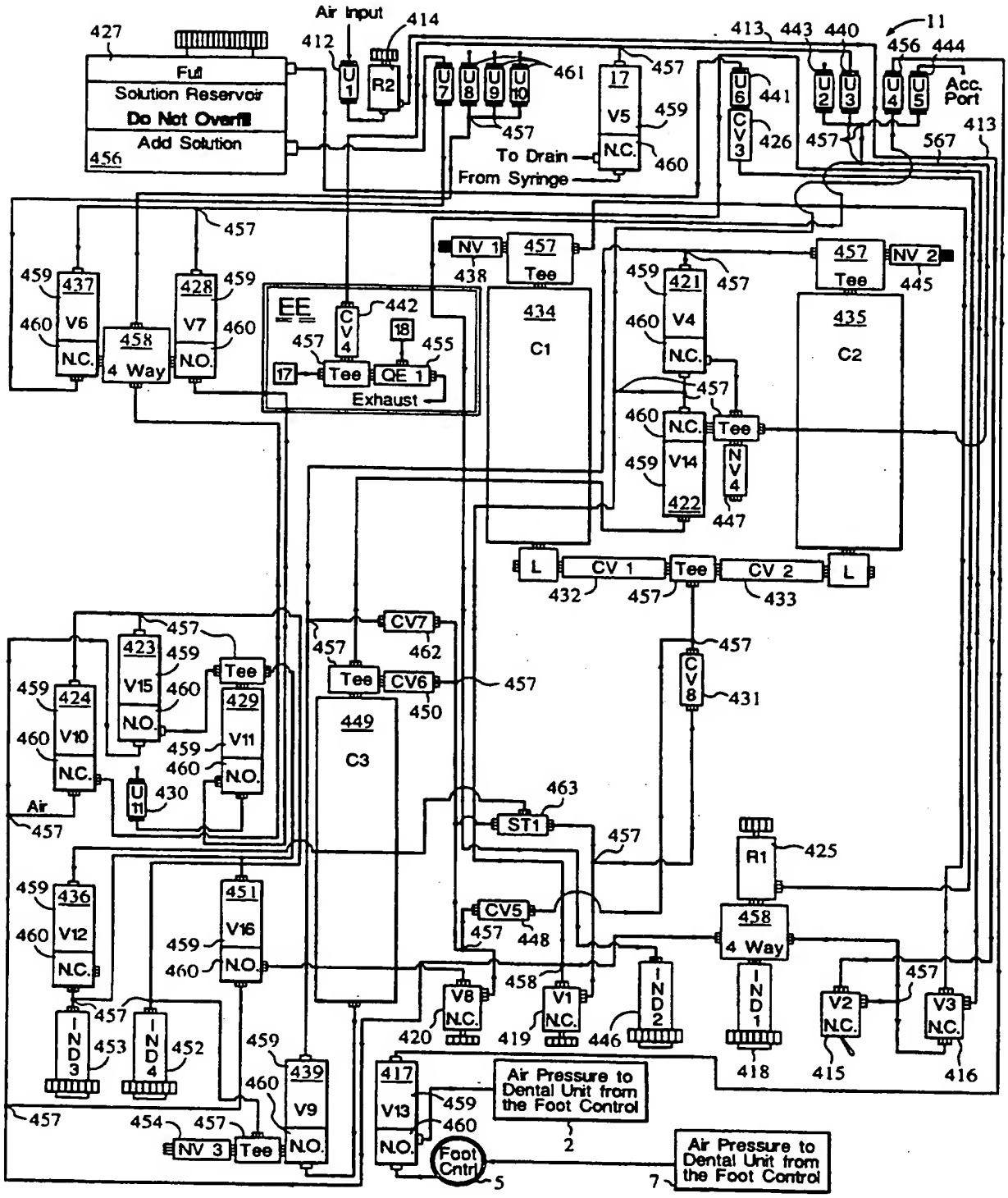


FIG. 4

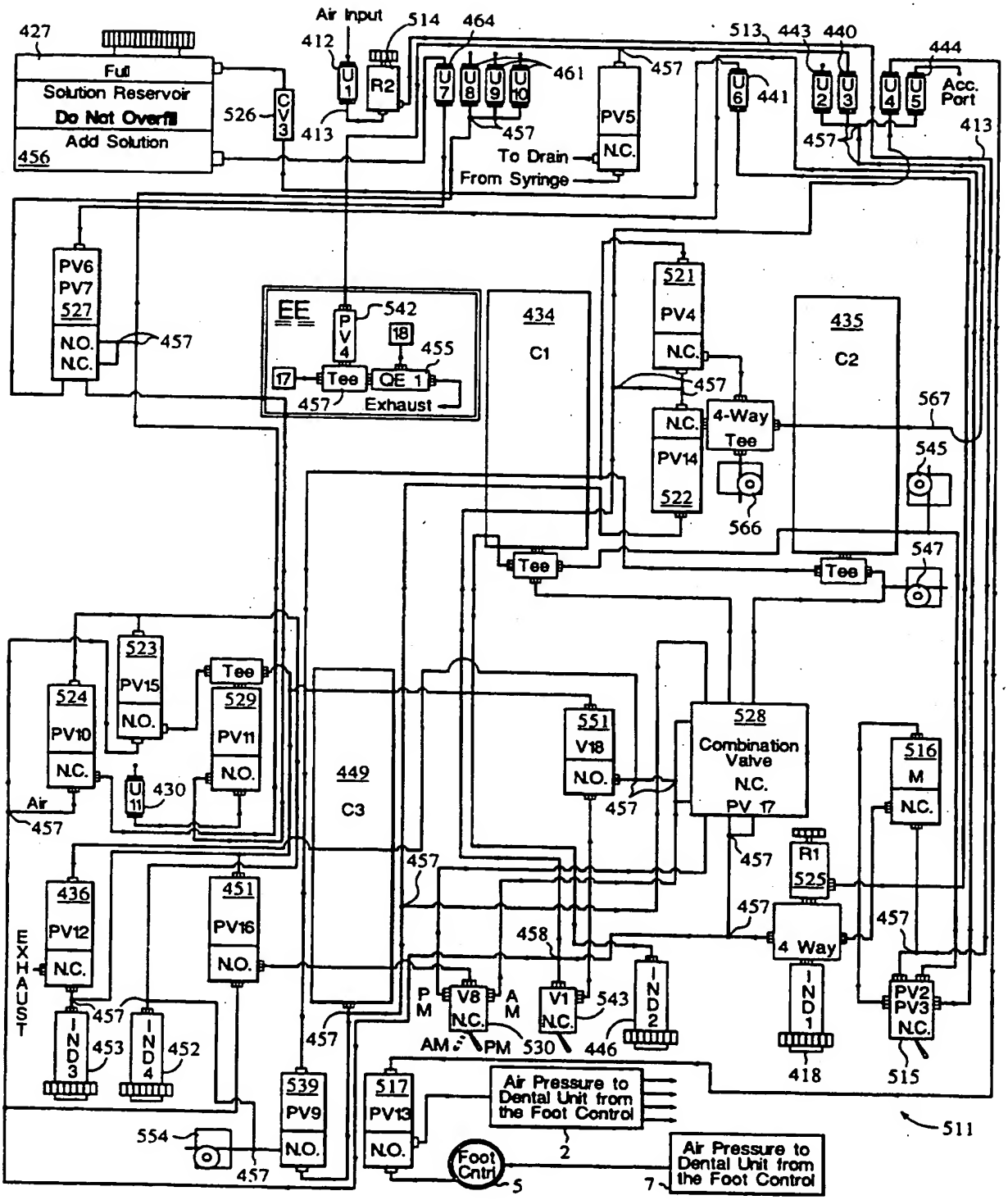


FIG. 5

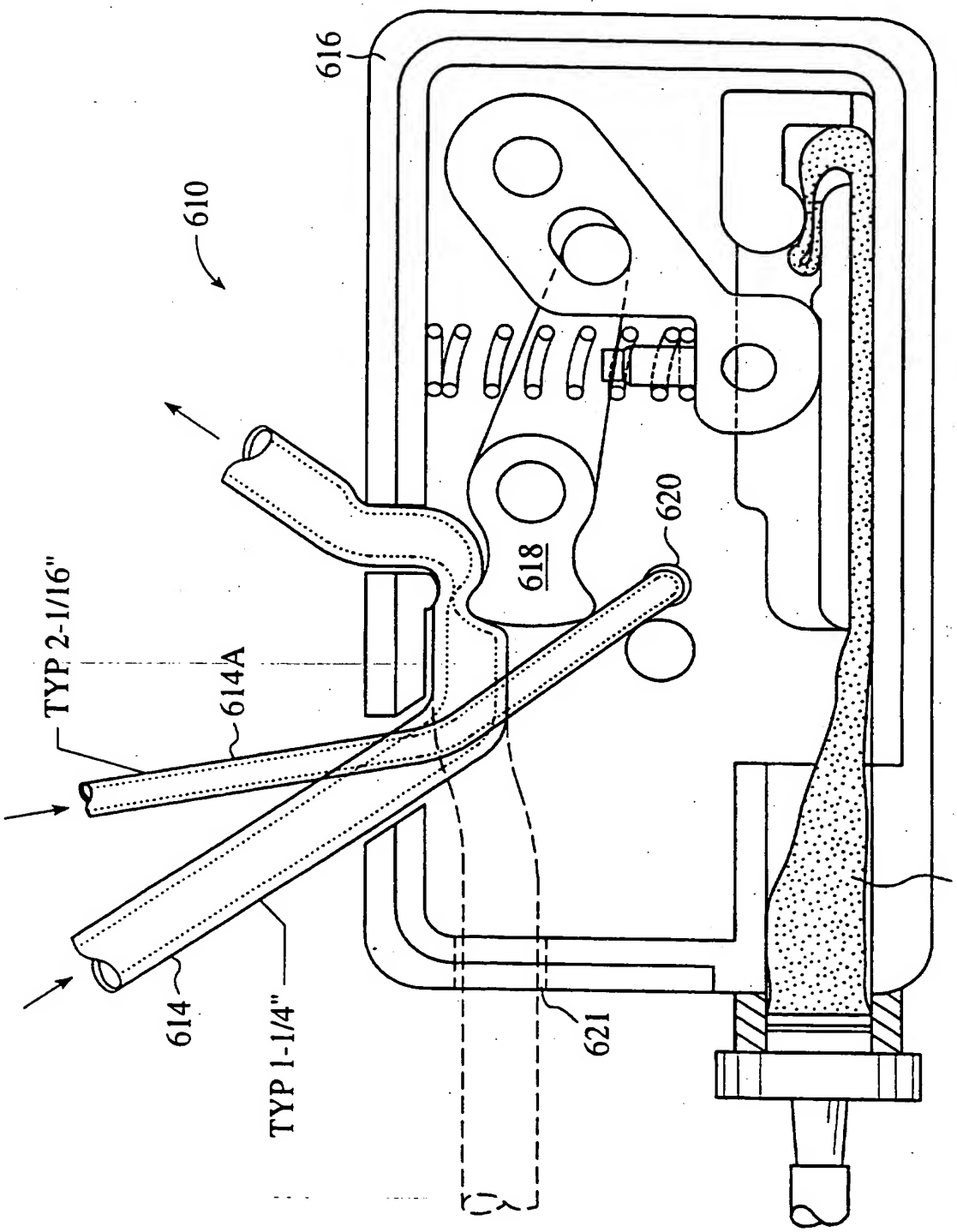


FIG. 6

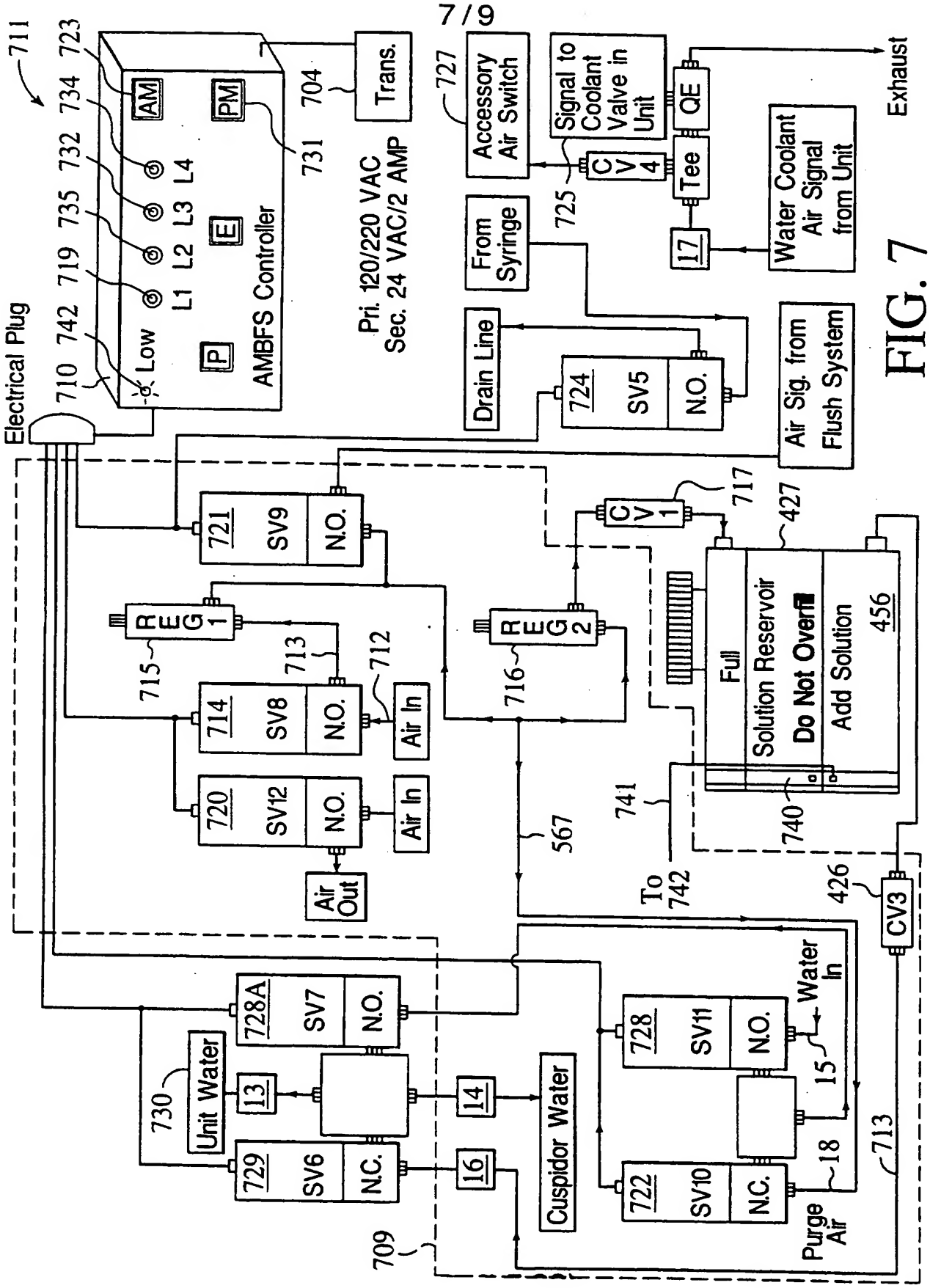


FIG. 7

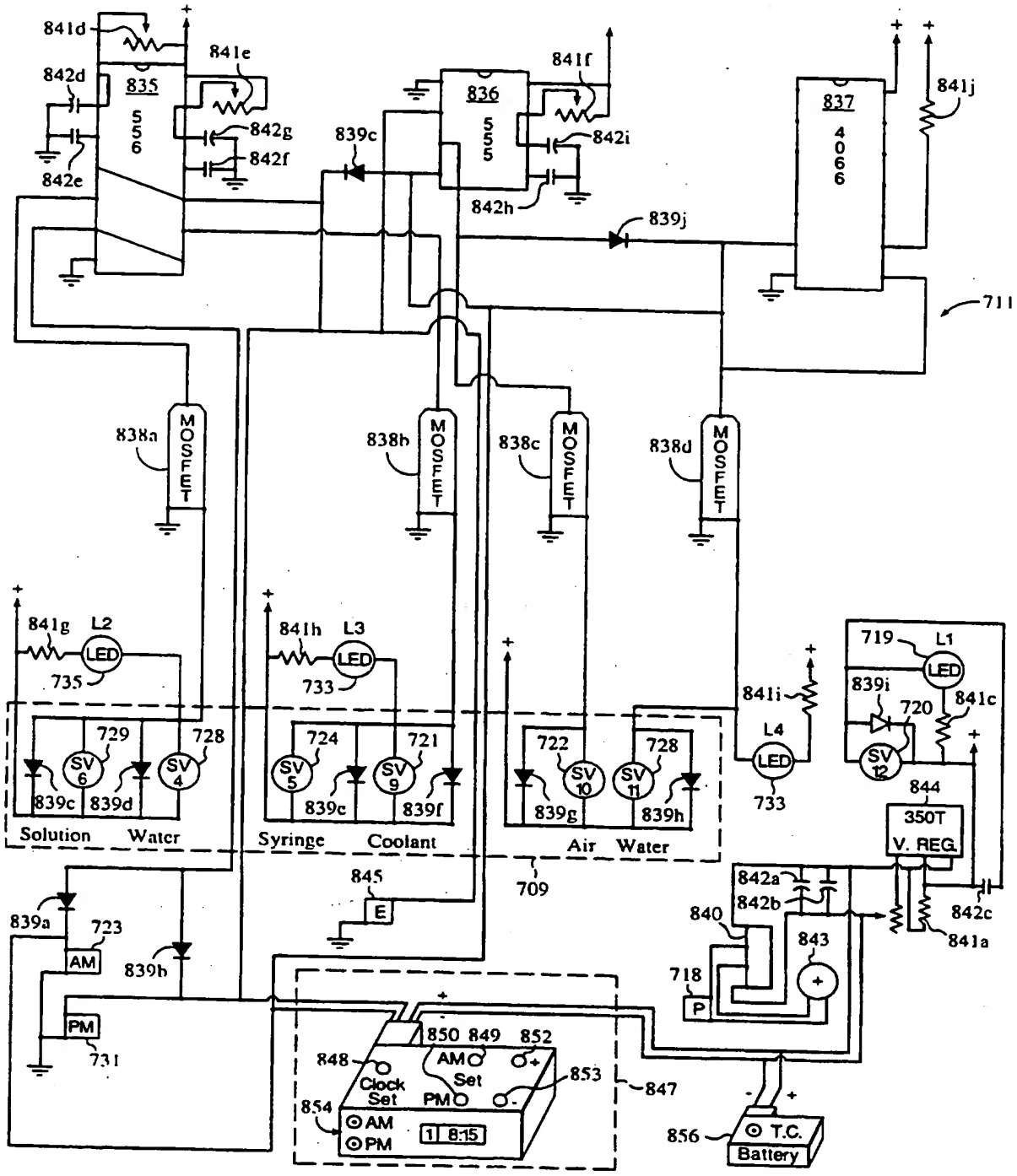


FIG. 8

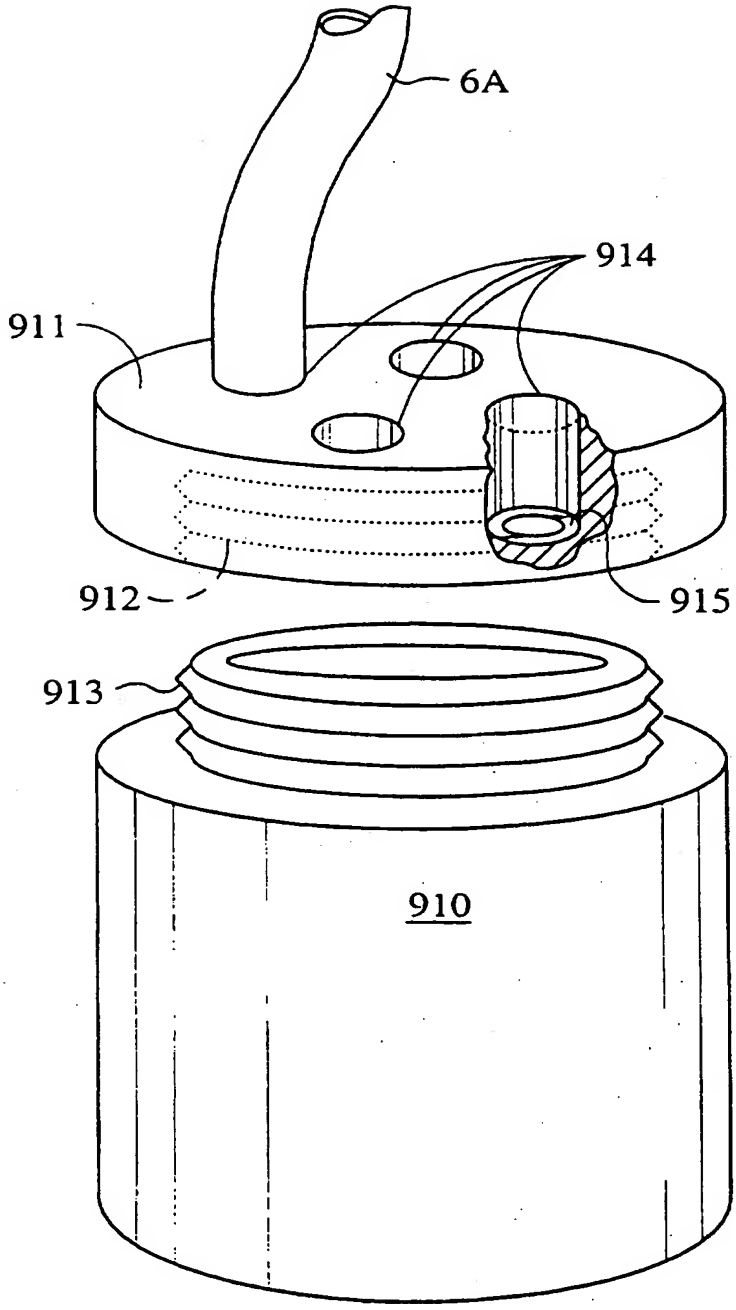


FIG. 9

FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/03969

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :A61L 2/16; B08B 3/00, 17/00; F16K 7/07, 31/126
US CL :422/28, 116, 292; 134/95.2; 251/5, 9, 58, 61

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 422/28, 105, 116, 292; 134/22.11, 22.12, 95.1, 95.2; 433/104; 251/5, 7, 9, 58, 61

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US, A, 4,752,444 (BOWEN ET AL.) 21 June 1988, fig. 1, #22,26,28-1,30-1,40,42, col. 1, lines 18-19, col. 2, lines 15-29, col. 3, lines 41-47, col. 5, lines 8-14, 30-36, 55-60, col. 6, lines 58-59.	11, 19, and 28-3 1 --- 1-10, 12-18, and 32-33
X --- Y	US, A, 4,990,087 (DE ROCCHIS ET AL.) 05 Feb 1991, col. 5, lines 53-57, 64-68, col. 6, lines 1-6, col. 7, lines 26-31, 38-41, col. 8, lines 18-20, 33-35, col. 11, lines 48-55.	24-27 --- 32
X --- Y	US, A, 5,026,020 (BETUSH) 25 June 1991, see entire document.	21 --- 22-23

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search	Date of mailing of the international search report
24 JUNE 1996	15.07.96

Name and mailing address of the ISA/US	Authorized officer
Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	THERESA T. SNIDER
Facsimile No. (703) 305-3230	Telephone No. (703) 308-0651

Form PCT/ISA/210 (second sheet)(July 1992)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/03969

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US, A, 4,545,956 (CISZEWSKI ET AL.) 08 Oct 1985, col. 3, lines 3 1-61, col. 4, lines 10-63.	24-27
X	US, A, 5,295,825 (BETUSH) 22 March 1994, see entire document.	21-23
Y	US, A, 5,305,983 (HAASE ET AL.) 26 April 1994, see entire document.	23